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Lanternfish larvae from the Agulhas current (SW Indian Ocean)*

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SUMMARY: This paper is presented as a guide to assist in identifying larval stages of lanternfish (family Myctophidae) of the Agulhas Current region. The work is based on the larvae collected during three cruises conducted off the eastern coast of South Africa from 29°S to 34°S in 1990 and 1991. The larval distributions obtained from these surveys are summarised briefly. Generally, only literature citations are given for species of the region whose larvae have been described previously. Descriptions are limited to those species for which complete larval development have not been published previously and to those species not known to spawn in the region, to compare larval features with those from regions where the species is known to spawn (*i.e.*, *Benthosema fibulatum*, *B. pterotum*, *Hygophum proximum*, *Lampadena luminosa*, *Myctophum selenops*, *Notoscopelus caudispinosus* and *Triphoturus nigrescens*). Also, diagnostic characters and illustrations are presented for species which may be difficult to identify in some developmental stages, particularly the early larval stages (*i.e.*, *Benthosema suborbitale*, *Bolinichthys* spp., *Ceratoscopelus townsendi*, *Diogenichthys panurgus*, *Myctophum phengodes*, *Lobianchia dofleini*, *L. gemellarii* and *Scopelopsis multipunctatus*).

Key words: Myctophidae. Fish larvae. SW Indian Ocean. Diagnosis early larval stages.

INTRODUCTION

Lanternfish are an important component of the mesopelagic and bathypelagic fauna of the Agulhas current waters (Hulley 1984a) (Table 1) and their larvae constitute from 10 to 50% of the total fish larvae collected during a series of research cruises conducted off the eastern coast of South Africa from 29°S to 34°S in 1990 and 1991 (Beckley and Van Ballegooyen 1992). Temporal and spatial patterns of distribution of these larvae were discussed by Olivar and Beckley (1994a). Identification was difficult because of the similarity of many of the small larvae collected during these cruises, especially of the early developmental stages. Nevertheless, larvae of 43 species belonging to the family Myctophidae were differentiated from these cruises. Larvae of several lanternfish species were identified for the first time and were described in separate papers (Olivar and Beckley, 1994b, 1995, 1997; Olivar and Palomera, 1994).

This paper is presented as an overall guide to the identification of lanternfish larval stages of the Agulhas Current. For identification to family level we direct the reader to general monographs, especially those that include Indian and Pacific Ocean species (Russell 1976; Miller *et al*. 1979; Fahay 1983; Leis and Rennis 1983; Moser *et al*. 1984; Ozawa 1986; Okiyama 1988; Leis and Trnski 1989; Matarese *et al*. 1986; Olivar and Fortuño 1991; Moser 1996; Neira *et al*. 1998). The general features

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TABLE 1. – Myctophid species recorded as adults in the Agulhas current (Hulley, 1984a) and presence of their larvae in the SE coast of South Africa (Olivar and Beckley, 1994a).

SPECIES	ADULTS	LARVAE	SPECIES	ADULTS	LARVAE
Benthosema fibulatum	+	+	*Lampadena luminosa*	+	+
Benthosema pterotum	–	+	*Lampadena notialis*	+	–
Benthosema suborbitale	+	+	*Lampadena speculigera*	+	–
Bolinichthys indicus	+	–	*Lampanyctus achirus*	+	+
Bolinichthys supralateralis	+	–	*Lampanyctus alatus*	+	+
Ceratoscopelus townsendi	+	+	*Lampanyctus ater*	+	+
Diaphus aliciae	+	–	*Lampanyctus australis*	+	–
Diaphus brachycepahus	+	+	*Lampanyctus festivus*	+	–
Diaphus diadematus	+	+	*Lampanyctus lepidolychnus*	+	+
Diaphus effulgens	+	–	*Lampanyctus nobilis*	+	+
Diaphus garmani	+	–	*Lampanyctus pusillus*	+	+
Diaphus hudsoni	+	–	*Lampanyctus turneri*	+	–
Diaphus jenseni	+	–	*Lobianchia dofleini*	+	+
Diaphus lucidus	+	+	*Lobianchia gemellarii*	+	+
Diaphus luetken	+	–	*Myctophum asperum*	+	+
Diaphus metapoclampus	+	–	*Myctophum aurolaternatum*	+	–
Diaphus mollis	+	+	*Myctophum nitidulum*	+	+
Diaphus nielseni	+	–	*Myctophum obtusirostre*	+	–
Diaphus parri	+	–	*Myctophum phengodes*	+	+
Diaphus perspicillatus	+	–	*Myctophum selenops*	–	+
Diaphus problematicus	+	–	*Myctophum spinosum*	+	+
Diaphus richardsoni	+	–	*Notolychnus valdiviae*	+	+
Diaphus splendidus	+	–	*Notoscopelus caudispinosus*	+	+
Diogenichthys atlanticus	+	+	*Notoscopelus resplendens*	+	+
Diogenichthys panurgus	+	+	*Scopelopsis multipunctatus*	+	+
Electrona rissoi	+	–	*Symbolophorus barnardi*	+	+
Gonichthys barnesi	+	–	*Symbolophorus evermanni*	+	+
Hygophum hanseni	+	–	*Taaningichthys bathyphilus*	+	–
Hygophum hygomii	+	+	*Triphoturus nigrescens*	+	+
Hygophum proximum	+	+			

of each genus are treated briefly, since they have been described extensively by Moser and Ahlstrom (1970; 1972; 1974; 1996) and Moser *et al*. (1984). For the subfamily Myctophinae information on the main sources of larval descriptions and new data on larval development are presented for several species belonging to *Benthosema*, *Diogenichthys*, *Hygophum*, *Myctophum* and *Symbolophorus*. Within Lampanyctinae similar kinds of information are given for several species of *Bolinichthys*, *Ceratoscopelus*, *Diaphus*, *Lampadena*, *Lampanyctus*, *Lobianchia*, *Notolychnus*, *Notoscopelus*, *Scopelopsis* and *Triphoturus*.

In general, diagnostic characters for larval identification and illustrations of larvae collected in the area are included. More detailed descriptions of larval development are given for those species for which complete larval development series have not been previously published (*e.g. Lampadena luminosa*). For those species not known to spawn in the region we include brief descriptions of morphology, pigmentation, and photophore development to compare larval features with those from regions where the species are known to spawn (*Benthosema fibulatum*, *B. pterotum*, *Hygophum proximum*, *Myctophum selenops*, *Notoscopelus caudispinosus*, *Triphoturus nigrescens*). A section on species comparisons is included for species whose larvae are especially difficult to identify.

A reference collection of the lanternfish larvae collected in the Agulhas current region during these cruises is deposited in the Ichthyoplankton Collection of the Institut de Ciències del Mar of Barcelona (ICICMB).

MATERIAL AND METHODS

The larvae examined in this study came from three cruises conducted in May/June 1990, October 1990, and February 1991 off the east coast of South Africa (Agulhas Current region). Ichthyoplankton samples were obtained with a Bongo net fitted with 0.5 mm mesh hauled obliquely from 80 m to the surface, where bottom depth permitted. The stations were arranged in a series of nine transects perpendicular to the coastline at isobaths of 50 m, 100 m, 500 m and 2000 m.

Larvae were preserved in 5% buffered saline formalin and measurements were made at least six months after collection and fixation at sea. Measurements were performed to an accuracy of 0.1 mm. Larval length refers to body length (BL), the distance along the midline of the body from the tip of the snout to the tip of the notochord in preflexion and flexion larvae, and to the posterior margin of the hypural elements in postflexion stages. Other measures recorded were: preanal length (PAL), the distance along the midline of the body from the tip of the snout to the vent; head length, the distance from the tip of the snout to the posterior margin of the cleithrum; body depth at pectoral (BDP), depth of the body at the base of the pectoral fin and eye diameter (ED).

The following photophore terminology is based on Moser and Ahlstrom (1972) and Fujii (1984): Br_2, second branchiostegal photophore; Dn, dorsonasal photophore; Op, opercular photophore; PO, pectoral photophores, a ventral series of photophores situated between the opercle and the bases of the pelvic fin; PVO, subpectoral photophores, located between the opercle and the pectoral fin; AOa, anterior anal photophores, series located on each side of the anal fin base; Vn, ventronasal photophore; PLO, suprapectoral photophore.

Larval nomenclature used in this paper follows Kendall *et al.* (1984). Abbreviations for meristic characters were the following: D, number of dorsal fin rays; A, number of anal fin rays; P, number of pectoral fin rays, GR, number of gill rakers. Information on adult meristic characters came from the following papers: Nafpaktitis and Nafpaktitis (1969); Wisner (1976); Nafpaktitis *et al.* (1977); Nafpaktitis (1978); Hulley (1981, 1984a, 1984b, 1986); Tsokur (1982); Bourret (1985); Moser and Ahlstrom (1996).

Within the descriptions we give information on adult distributions in the area, this information was obtained from Hulley's (1984a) study, based on adult lanternfishes obtained during 5 cruises off the east coast of South Africa from 27°S to 34°S.

DESCRIPTIONS OF LARVAE

SUBFAMILY MYCTOPHINAE

Benthosema fibulatum (Gilbert and Cramer, 1897)
(Fig. 1)

The species has a tropical subtropical distribution, but a few immature adults have been collected in the region (Hulley 1984a). Counts: D 12-14, A 18-20, P 14-17, GR 6-7+1+12-16, vertebrae 31-32.

Larvae appeared on all three cruises. Spatial distribution extended from north to south and from coastal stations (50 m) to the most offshore ones (2000 m). Total larvae examined: 253, 3.0-12.5 mm BL. Identification was based on the descriptions of Moser and Ahlstrom (1974); Pertseva-Ostroumova (1974) and Ozawa (1986).

Morphology

Body relatively slender (BDP <20% BL in preflexion and flexion stages); gut extending to the midpoint of the body; eyes slightly ovate; notochord flexion begins around 5.0 mm and the urostyle is flexed at 6.0 mm.

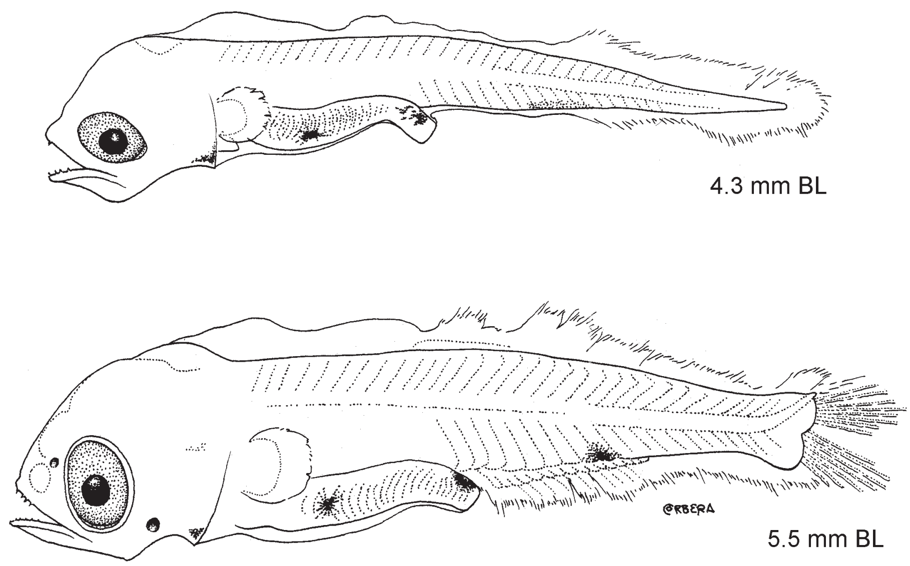

FIG. 1. – Developmental stages of *Benthosema fibulatum* from the Agulhas current region: 4.3 mm and 5.5 mm. ICICMB 170/AGU.

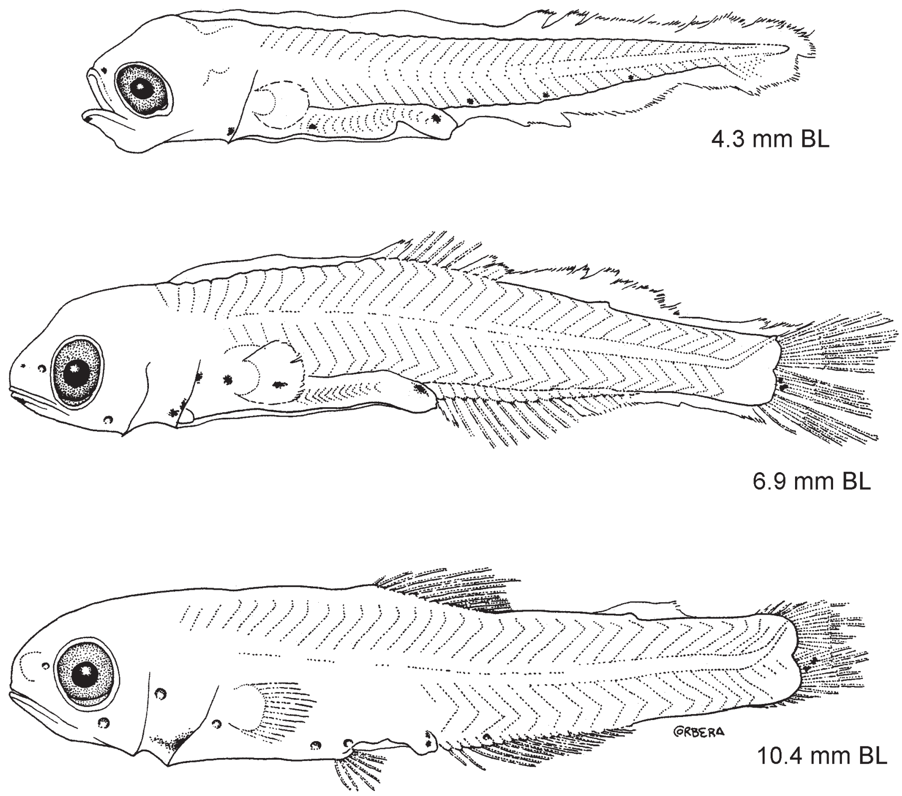

FIG. 2. – Developmental stages of *Benthosema pterotum* from the Agulhas current region: 4.3 mm, 6.9 mm and 10.4 mm. ICICMB 172/AGU.

Pigmentation

Blotch in ventral midline anterior to the cleithral symphysis; one stellate melanophore on the lateral wall of the gut midway between the anus and the cleithral symphysis, and another one on the free terminal section of the gut; in larvae <4 mm, three or four postanal melanophores on the ventral midline of the body, later coalescing to one; embedded in the otic region; in some larvae >7.5 mm BL one melanophore is present on the ventral margin of the caudal peduncle.

Photophore development

Dn appears at 5-6 mm; PO_5 at 6 mm.

Benthosema pterotum (Alcock, 1891)
(Fig. 2)

No adults of the species have been reported off the eastern coast of South Africa (Hulley 1984a; 1986). This is a common species of the Arabian Sea and the nearest recorded specimens were from Mozambique waters (Dalpadado, 1988). Counts: D 12-14, A 19-22, P 12-14, GR 6-9+1+14-19, myomeres 12-14 to 18-20.

Larvae of *B. pterotum* were present on all three cruises, with highest abundance in the May/June cruise. They were collected mainly over the shelf, along the entire coast, with highest abundances at the 50 m stations. Total larvae examined: 475, 2.4-10.4 mm BL. Identification was based on the descriptions of Moser and Ahlstrom (1974) *(B. panamense*); Tsokur (1982) and Ozawa (1986).

Morphology

Body moderately slender (BDP 14-19% BL); gut extends to slightly behind the midpoint of the body (PAL 52-57% BL); notochord flexion begins around 5.0 mm and the urostyle is flexed at 6.0 mm.

Pigmentation

Blotch anterior to the cleithral symphysis present in all larval stages; a melanophore on the lateral wall of the gut and another one on the free terminal section of the gut; a melanophore on the tip of the lower jaw, and a pair on the snout; all above melanophores indistinct or absent in larvae >10 mm; three or four melanophores on the midventral line of the tail present in very early larvae; these coalesce to one in larvae 4.5 to 5.5 mm BL, located *ca*. 7 myomeres pos-

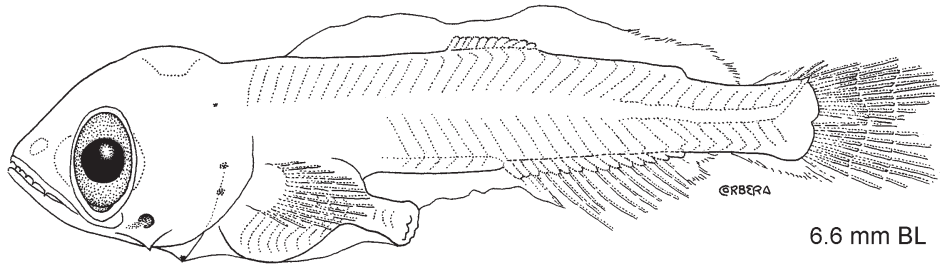

FIG. 3. – Larva of *Benthosema suborbitale* from the Agulhas current region: 6.6 mm. ICICMB 174/AGU.

terior to the anus; this melanophore seldom visible in larger larvae.

Photophore development

Br_2 beginning to form at 5.0 mm; Br_2 and Dn begin forming at *ca*. 5.7 mm; PO_5 at 8.4 mm.

Comparative remarks

No pigmentation present on the tip of the lower jaw and snout in *B. fibulatum*, but present in *B. pterotum*. Melanophores large and often stellate in *B. fibulatum* and small and inconspicuous in *B. pterotum*. In *B. pterotum*, postanal melanophore on the ventral midline of the body disappears in larvae >6 mm, but is still present in transforming larvae of *B. fibulatum*. Body slightly more slender in *B. pterotum* than in *B. fibulatum*. Photophores larger in *B. fibulatum*. Order of photophore development differs between the two species (see table 1 of Moser and Ahlstrom 1974). Br_2, Dn and PO_5 appear earlier in *B. fibulatum* than in *B. pterotum*, followed by PVO_1 and Op_2 in *B. pterotum* and PO_1 and AOa_1 in *B. fibulatum*.

Eyes less narrow in *Benthosema* than in *Hygophum* larvae. Dorsal fin develops earlier in *Benthosema* than in *Hygophum*. Photophores (in addition to Br_2) develop earlier in *Benthosema* than in *Hygophum*.

Benthosema suborbitale (Gilbert, 1913) (Fig. 3)

Adults of this species have a broadly tropical distribution, they were the most common *Benthosema* found in the area by Hulley (1984a). Counts: D 11-14, A 16-19, P 12-15, vertebrae 33-35.

Larvae of *B. suborbitale* were present on all cruises. Their abundances were never very high (maximum of 49 larvae under 10 m^2), but they occurred frequently throughout the region, less commonly at the most offshore stations. Total larvae examined: 65, from preflexion to the end of flexion stages. They were identified through the descriptions of Moser and Ahlstrom (1974, 1996), Pertseva-Ostroumova (1974), Badcock and Merret (1976), Shiganova (1977) and Ozawa (1986).

Diagnostic characters

Larvae of *B. suborbitale* are easily separated from the other two species of the genus discussed above by morphology (mainly head and gut region), the pronounced space between the anus and the anal fin and reduced pigmentation. The gut is not straight as in the other two species. The number of myomeres is greater than in the other two species. Also, photophore development is different, Br_2, PO_1, PO_2 are the first to appear.

The early presence of Br_2 (at *ca*. 3.0 mm BL), the shape of this photophore, the pigmentation on the cleithral symphysis, the shape of the gut and the wide space between anus and anal fin differentiate these larvae from those of *Electrona rissoi*, a species not found among the larvae collected in the present surveys, but present as adults in the southwest Indian Ocean (Hulley 1986).

Diogenichthys atlanticus (Tåning, 1928) and ***D. panurgus*** Bolin, 1946 (Fig. 4)

Two species of this genus *D. atlanticus* and *D. panurgus* have been recorded in the Agulhas Current region (Hulley 1984a). Counts for *D. atlanticus*: D 10-12, A 14-18, P 10-14, GR 2+1+9-12, vertebrae 31-35. Counts for *D. panurgus*: D 10-12, A 15-17, P 10-11, GR 2-3+1+8-10.

Larvae of both species appeared on the three cruises, but *D. panurgus* was more abundant in May/June 1990. Both species were more abundant north of East London. Total *D. atlanticus* larvae

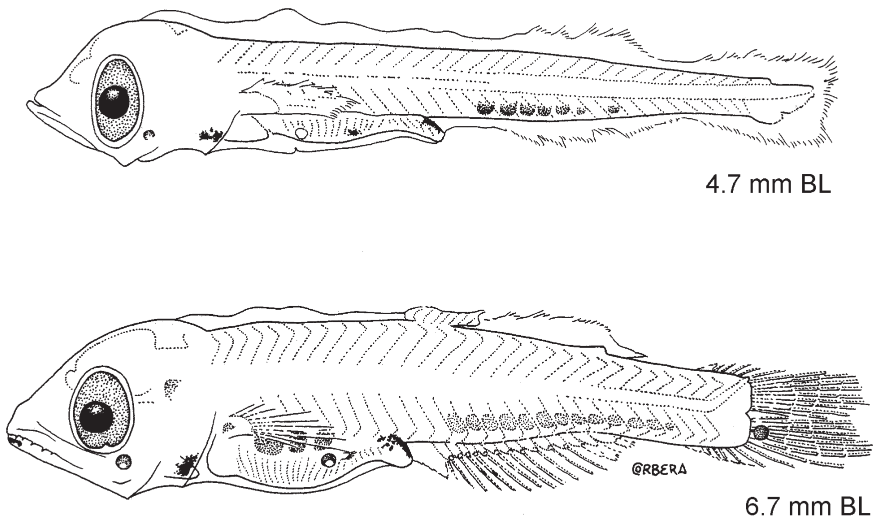

FIG. 4. – Developmental stages of *Diogenichthys panurgus* from the Agulhas current region: 4.7 mm and 6.7 mm. ICICMB 176/AGU.

examined: 52, from preflexion to postflexion stages. The complete larval series of development (from larvae of 3.6 mm to juveniles of 16.0 mm) was described by Moser and Ahlstrom (1970). Other larval descriptions have been published by Pertseva-Ostroumova (1974); Shiganova (1977) and Ozawa (1986). Total *D. panurgus* larvae examined: 265, *ca.* 3.0 to 9 mm BL. Larvae were identified using the description published by Pertseva-Ostroumova (1974).

Diagnostic characters

Both species are easily differentiated when >5 mm by the presence of a barbel at the symphysis of the lower jaw in *D. atlanticus,* a feature absent in *D. panurgus*. Smaller stages may be differentiated by the presence of pigmentation at the symphysis of the lower jaw in *D. panurgus*, and its absence in *D. atlanticus*. Furthermore, in larvae <5 mm the Br_2 photophore is already developed in *D. panurgus*, but appears later in *D. atlanticus*.

Genus ***Hygophum***

Adults of three species of the genus *Hygophum* have been collected in the Agulhas Current region: *H. hygomii* a subtropical species, *H. hanseni* a "South Temperate" species (Hulley, 1981), and *H. proximum* a tropical species. *H. hygomii* is the most abundant, and only a few immature individuals of the other two species were reported by Hulley (1984a).

H. hygomii (Lütken, 1892) and ***H. proximum*** Bekker, 1965 (Fig. 5)

Two types were present among the larvae examined. The most abundant corresponded to *Hygophum hygomii*. Total larvae examined: 1668, 2.5-13.5 mm BL. These larvae were described by Olivar and Palomera (1994). The other *Hygophum* larvae belonged to *Hygophum proximum*. Total larvae examined: 33, 3.0-10.8 mm BL. Counts for *Hygophum hygomii*: D 13-15, A 20-23, P 14-17, GR 4-6+1+13-16, vertebrae 36-37. Counts for *Hygophum proximum*: D 12-14, A 18-21, P 13-15, GR 3-5+1+11-14, vertebrae 36.

Larvae of *H. hygomii* occurred along the entire survey area except at the southern inshore sector. They were especially abundant in the May/June 1990 cruise. *H. proximum* larvae also occurred on the three cruises, but were more common during the February 1991 cruise and were mostly concentrated in the northern sector. A number of descriptions are available for larvae of *H. hygomii* and *H. proximum* (Moser and Ahlstrom 1974, 1996; Pertseva-Ostroumova 1974; Shiganova 1977; Berdar and Cavaliere 1979; Ozawa 1986; Olivar and Palomera 1994; Moser and Ahlstrom 1996). The diagnostic characters of *H. proximum* larvae that differentiate them from *H. hygomii* are given below.

Morphology

Slender body in preflexion and flexion stages (BDP <20% BL), and moderately slender in post-

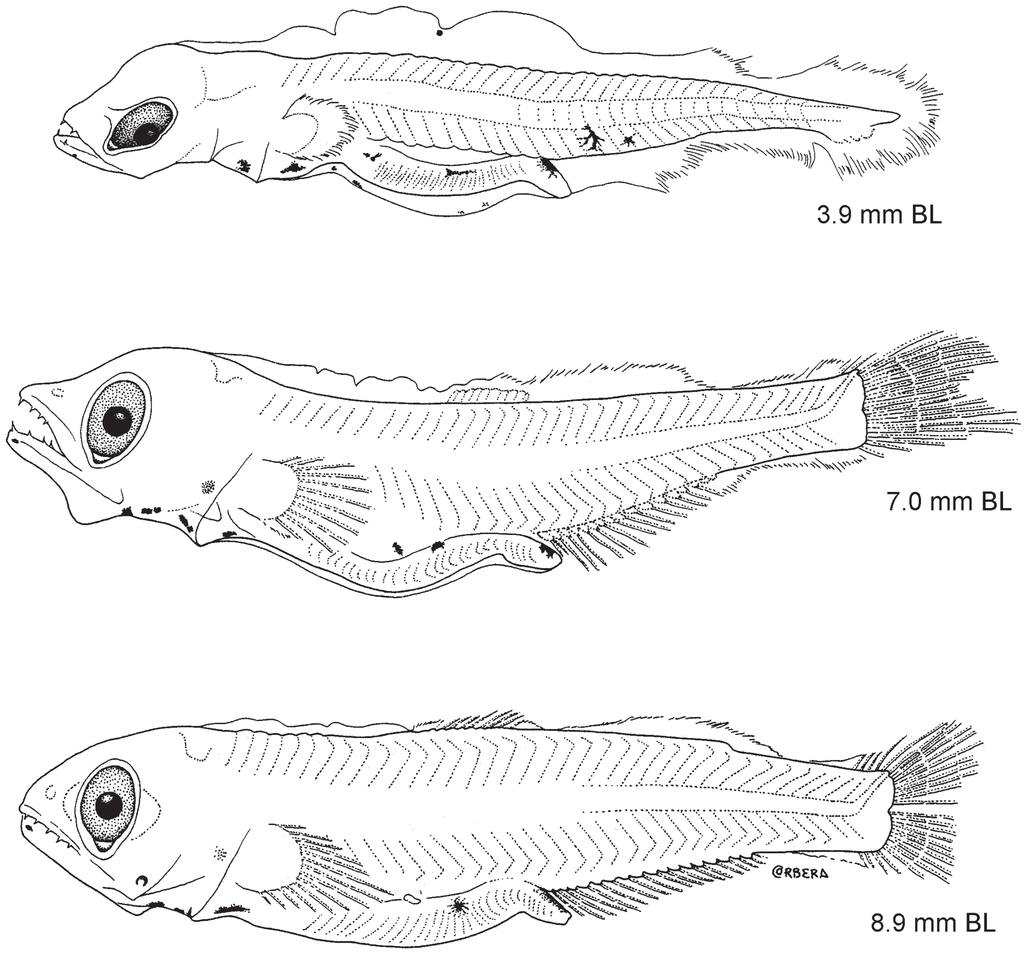

FIG. 5. – Developmental stages of *Hygophum proximum* from the Agulhas current region: 3.9 mm, 7.0 and 8.9 mm. ICICMB 178/AGU.

flexion larvae (BDP <24% of BL in larvae of 11 mm); gut straighter and preanal length greater in *H. proximum* (>60% BL) than in *H. hygomii* (BDP <59% BL); in *H. hygomii* the dorsal fin extends posterior to the anus, while in *H. proximum* the anus is below the dorsal fin insertion; notochord flexion begins around 5.5 mm and the urostyle is flexed at 6.5 mm.

Pigmentation

The pigmentation pattern is a useful character in the identification of preflexion and flexion stages. *H. proximum* larvae have one or two ventral tail melanophores near the anus (*ca*. 2-3 myomeres after the anus), whereas *H. hygomii* larvae have only one stellate melanophore 6-8 myomeres posterior to the anus; no pigment on pectoral fin rays in *H. proximum*, whereas melanophores scattered on pectoral rays in *H. hygomii;* a small melanophore at base of caudal fin in some flexion larvae of *H. proximum*, this pigmentation never present in *H. hygomii* larvae.

Genus ***Myctophum***

Table 2 lists adults of this genus reported by Hulley (1984a; 1986) in the SW Indian Ocean. Larval morphology and pigmentation pattern of some *Myctophum* species are distinctive enough to allow relatively easy identification (see diagnostic characters listed in Table 2).

Myctophum asperum Richardson, 1845

Counts: D 10-14, A 16-20, P 12-16, GR 3-5+1+9-12.

Two larvae of this species (*ca*. 3 mm BL) were collected in May/June 1990 and another one in February 1991 (4.4 mm BL). They matched the descriptions given by Moser and Ahlstrom (1974); Pertseva-Ostroumova (1974) and Ozawa (1986).

TABLE 2. – Main pigmentation and morphological features useful to differentiate larvae of the *Myctophum* species that may occur in the Agulhas current region.

	PIGMENTATION					
	Tail	Caudal	Anterior to dorsal fin	Pectoral bases	Pectoral rays	Above anus
M. asperum	+	+	+	+	+	+
M. aurolaternatum	+	–	–	–	–	+
M. nitidulum	+	–	–	+	+	+
M. obtusirostre	–	–	–	–	–	–
M. phengodes	–	–	–	+	+	–
M. selenops	–	–	–	+	+	–
M. spinosum	+	+	+	–	–	+

	MORPHOLOGY			
	BDP/BL	Eyes	Gut	Br_2
M. asperum	20-40%	sessile and not very narrow	deep	7 mm
M. aurolaternatum	< 10%	stalked and narrow	straight	>20 mm
M. nitidulum	15-30%	stalked and narrow	deep	8 mm
M. obtusirostre	20-40%	sessile and not very narrow	deep	4.5 mm
M. phengodes	20-30%	sessile and narrow	relatively straight	6.5 mm
M. selenops	20-40%	very prominent choroid	deep	5 mm
M. spinosum	20%	small and prominent choroid	relatively straight	9 mm

Myctophum nitidulum Garman, 1899

Counts: D 12-14, A 18-21, P 12-15. GR 4-8+1+11-18.

Larvae belonging to this species occurred on the three cruises, mainly north of Mbashe and offshore of the 200 m isobath. Total larvae examined: 31, 3.5-10.4 mm BL. Larvae were similar to those described by Moser and Ahlstrom (1974, 1996); Pertseva-Ostroumova (1974) and Ozawa (1986).

Myctophum phengodes (Lütken, 1892) (Fig. 6)

Counts: D 12-14, A 20-22, P 15-17, GR 7-8+1+16-18.

Total larvae examined: 13, 4.5 - 6.5 mm BL. They were collected during the October 1990 and February 1991 cruises at stations located along the 500 and 2000 m isobaths. Identification of Agulhas larvae was based on the 9.8 mm larva described by Moser and Ahlstrom (1974).

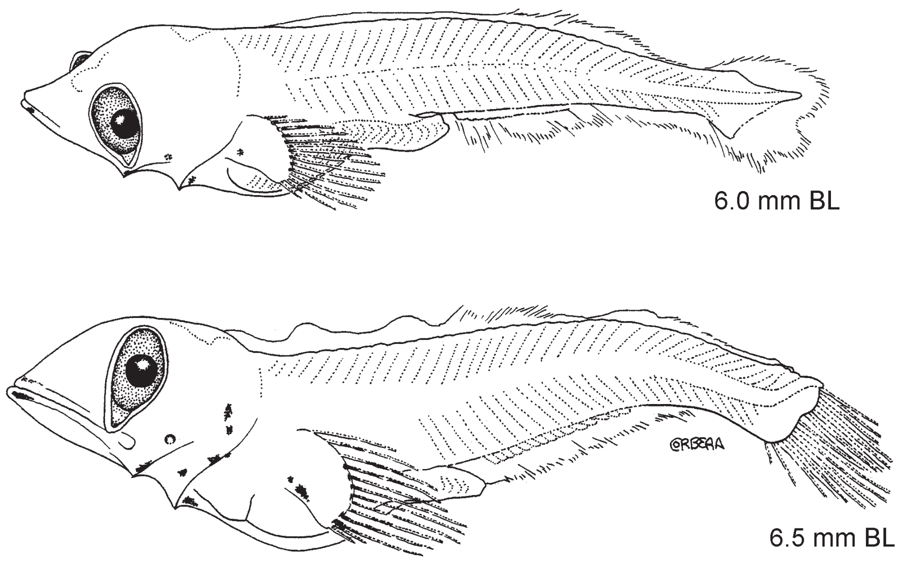

FIG. 6. – Developmental stages of *Myctophum phengodes* from the Agulhas current region: 6.0 mm and 6.5 mm. ICICMB 179/AGU.

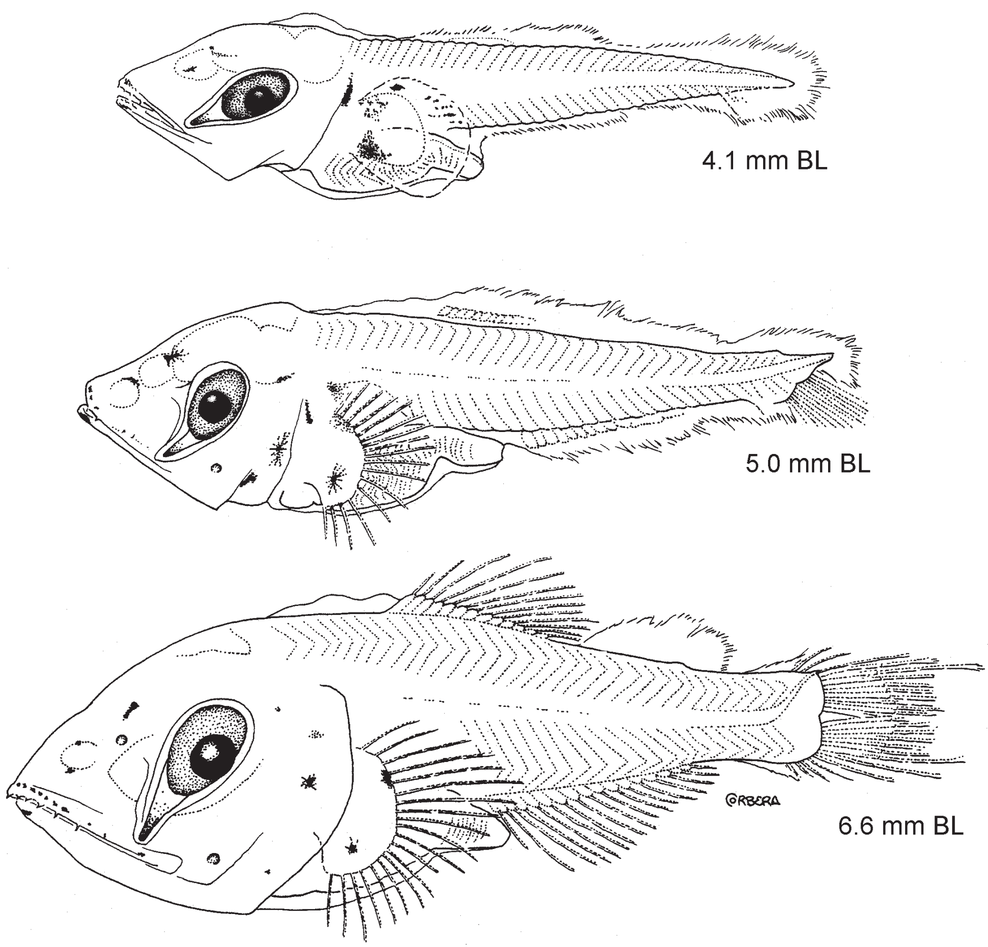

FIG. 7. – Developmental stages of *Myctophum selenops* from the Agulhas current region: 4.1 mm, 5.0 mm and 6.6 mm. ICICMB 181/AGU.

Diagnostic characters

Useful characters for species identification are the presence of melanophores at the margin of the pectoral fin base and lack of other larval pigmentation.

Myctophum selenops Tåning, 1928
(Fig. 7)

No adults of this species were reported by Hulley (1984a) during the Meiring Naude cruises in this same area, but the species has been found at southern localities associated with Agulhas waters (Hulley 1981; 1986). Counts: D 12-14, A 17-19, P 15-18, GR 6-7+1+14-17.

This was the most common *Myctophum* larva collected on the three cruises. They occurred in the study region during the three cruises, with highest abundances in May/June 1990. Total larvae examined: 191, 3.0-7.2 mm BL. Identification based on the description of a 7.8 mm postflexion larva in Moser and Ahlstrom (1974).

Morphology

The anterior region of the body prominent from early stages; snout pointed and head relatively large and deep; relative head length increases as development progresses (31-40% of BL); body relatively deep at pectoral, BDP increases from 23% of BL in preflexion larvae to 37% of BL in 7.2 mm BL larvae; preanal length to the midpoint of the body in preflexion larvae (PAL 48% of BL) and to >60% of BL at 7.2 mm; eyes very narrow and have a prominent mass of choroid tissue. Notochord flexion begins at *ca*. 5.0 mm and the urostyle is flexed at 6.0 mm.

Pigmentation

No pigmentation present on tail; a single stellate melanophore present ventrally on trunk; a melanistic blotch located ventrally on base of the pectoral fin, and another one dorsally on inner side of the fin; another group of melanophores present on opercular margin.

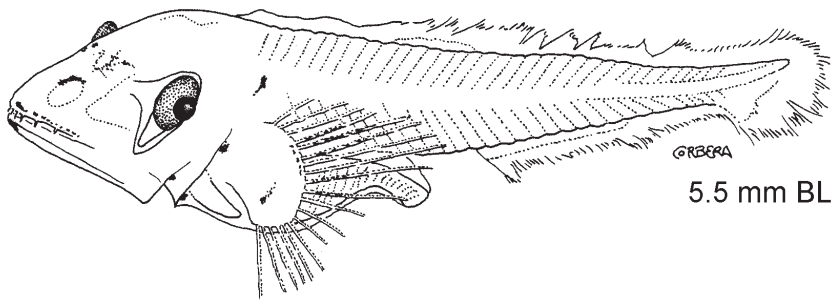

FIG. 8. – Larva of *Myctophum* sp. from the Agulhas current region: 5.5 mm. ICICMB 183/AGU.

Photophore development
Br_2 is already present in 4.5 mm BL larvae; Vn appear at *ca*. 5.9 mm. No other photophores were present in the 7.2 mm larva.

Myctophum spinosum (Steindachner, 1867)

Counts: D 12-14, A 18-20, P 13-15, GR 5-8+1+12-18.

Two larvae of this species appeared during May/June 1990 survey (3.4 and 5.3 mm BL) and three more larvae during the February 1991 cruise (6.1, 8.4 and 9 mm BL). These larvae were identified with the descriptions of Moser and Ahlstrom (1974); Pertseva-Ostroumaova (1974) and Ozawa (1986).

Myctophum sp.
(Fig. 8)

Seven larvae identified as *Myctophum* sp. occurred in the samples (from 4 to 5.5 mm BL). They resemble *M. phengodes* in their slight pigmentation. The main differences are the smaller eyes and the pigmentation between the eyes in these larvae.

Genus ***Symbolophorus***

Two species of *Symbolophorus* have been reported in the Agulhas current region, the subtropical *S. barnardi* and the tropical *S. evermanni,* though no mature individuals of the latter have been found. Larvae of both species occurred in our samples. Olivar and Beckley (1994b) give a detailed description of them together with comparative comments on larvae of other *Symbolophorus* species that may occur around southern Africa (see summary in Table 3).

SUBFAMILY LAMPANYCTINAE
Genus ***Bolinichthys***
(Fig. 9)

Larvae of *Bolinichthys indicus* and *B. supralateralis*, the two species of this genus reported in the area (Hulley 1984a) are undescribed. A few larvae

TABLE 3. – Main pigmentation and morphological features useful to differentiate larvae of the *Symbolophorus* species that may occur in the Agulhas current region.

	PIGMENTATION			
	Ventral midline preflexion	Ventral midline flexion-8.5 mm	Melanophores outlining pectoral bases	Lateral gut
S. barnardi	>10 melanophores	8-10 melanophores	+	>5
S. boops	>8 melanophoes	0-7 melanophores	+	<5
S. evermanni	<7 melanophores	0-2	-	<5
	MORPHOLOGY			
	PAL/BL preflexion-flexion	PAL/BL at 8.5 mm	Notochordal flexion	Br_2
S. barnardi	47-63%	64%	7-8 mm	Not before 9 mm
S. boops	46-59%	59%	6.5-7.5 mm	*ca*. 9 mm
S. evermanii	62-63%	63%	5.5-6.5 mm	6.5-7 mm

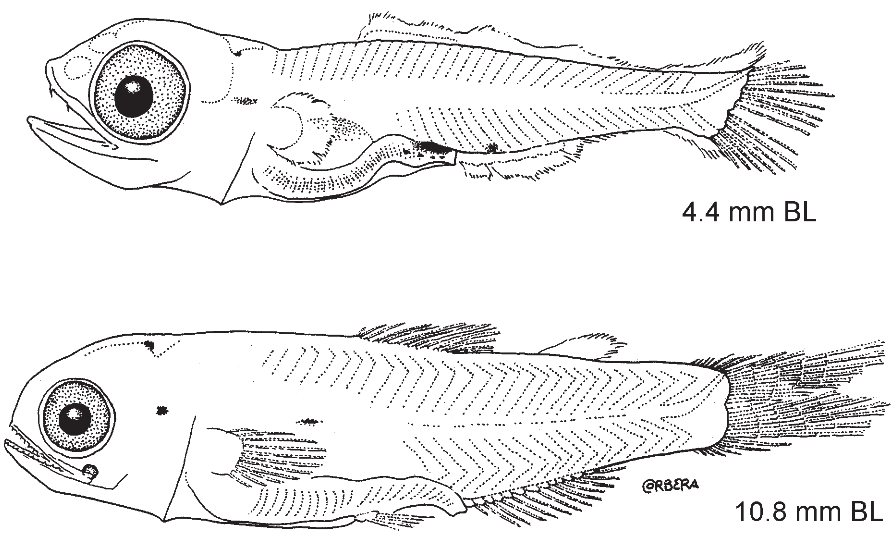

FIG. 9. – Developmental stages of *Bolinichthys* spp. from the Agulhas current region: 4.4 mm and 10.8 mm. ICICMB 184/AGU.

(19) belonging to this genus appeared in the surveys, the majority of them during the February 1991 cruise. Larval sizes ranged from 4.1 to 10.8 mm BL. We could not identify them to species nor sort them into more than one type.

Diagnostic characters

Larvae of this genus are characterised by large, round eyes, together with pigmentation above the brain and embedded in the otic region (Moser *et al.* 1984), and absence of pigmentation at the cleithral symphysis.

Ceratoscopelus townsendi (Eigenmann and Eigenmann, 1889) (Fig. 10)

This is the only species of the genus in the area. Counts: D 13-15, A 13-16, P 12-15, GR 3-5+1+8-11.

Larvae of *C. townsendi* were collected during the three cruises, mainly offshore of the 50 m isobath. Total larvae examined: 43, 3.0-13.7 mm BL. The main characters referred to in Miller *et al.* (1979); Moser *et al.* (1984) and Ozawa (1986) are useful in differentiating flexion and postflexion larvae from other species. Miller *et al.* (1979) described early

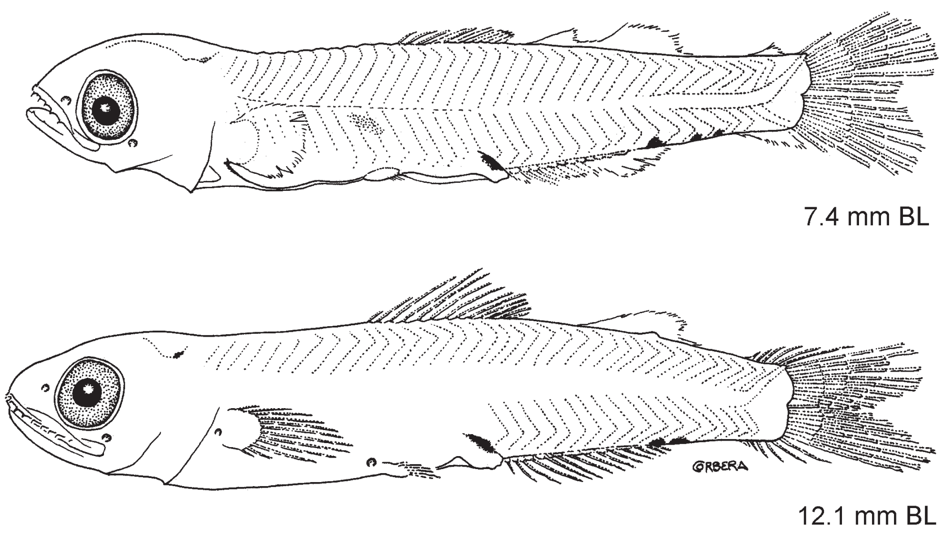

FIG. 10. – Developmental stages of *Ceratoscopelus townsendi* from the Agulhas current region: 7.4 mm and 12.1 mm. ICICMB 185/AGU.

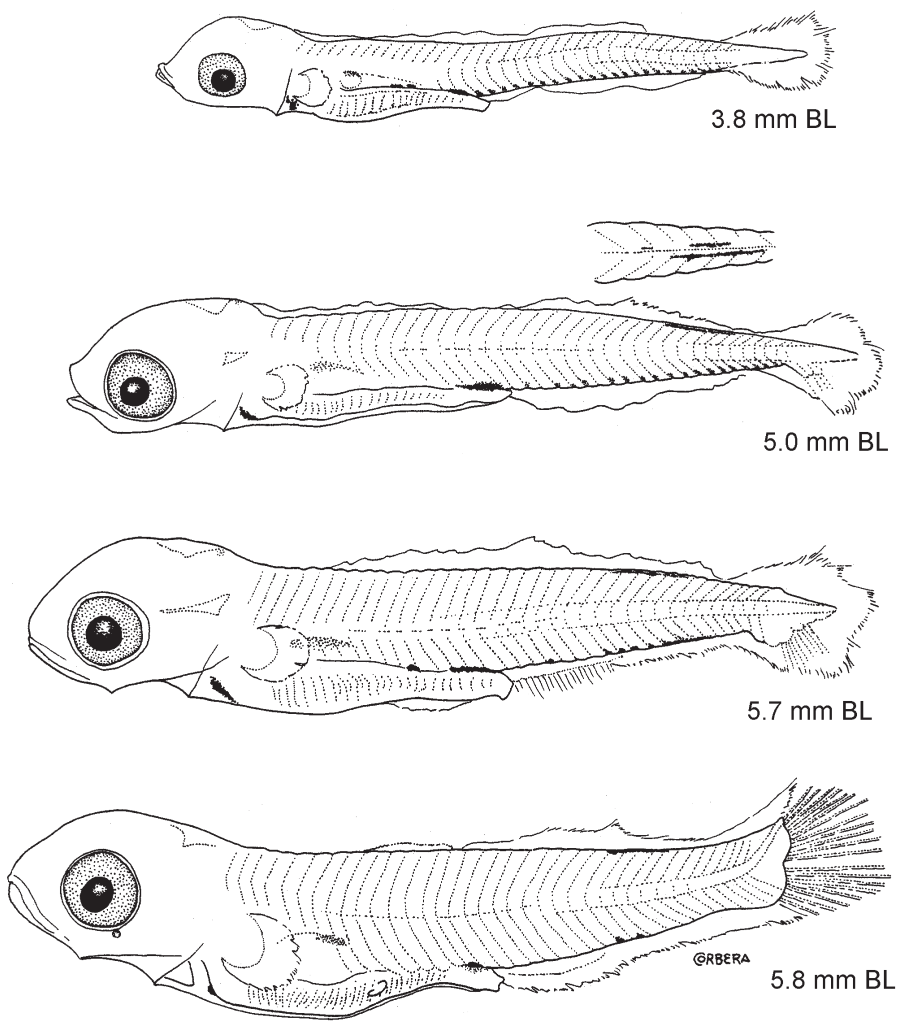

FIG. 11. – Preflexion and flexion developmental stages of *Lampadena luminosa* from the Agulhas current region: 3.8 mm, dorsal and lateral view of a 5.0 mm larva, 5.7 mm and 5.8 mm. ICICMB 187/AGU.

larvae from the mid-Pacific and Moser and Ahlstrom (1996) described the complete developmental series for larvae from the California Current region. We compare the main features of our larvae with these previous descriptions.

Diagnostic characters

Eyes slightly elliptical in early larvae; no pigmentation on the cleithral symphysis; a paired melanophore present at the anus; two to three melanophores on the midventral line of the body posterior to the anal fin; larger larvae of this species more rounded in cross-section (less compressed) than those of other species.

Comparative remarks

Differences with *B. pterotum*: No pigmentation on the cleithral symphysis in *Ceratoscopelus;* melanophores on the ventral midline more numerous in *C. townsendi* than in *B. pterotum* larvae. Sequence of photophore development in *Ceratoscopelus*: Br_2, Vn, PLO, PO_5, and in *B. pterotum*: Br_2, Dn, PO_5 , PVO_1.

Larvae of *C. townsendi* differ from *Bolinichthys* mainly in the smaller and less rounded eyes in *Ceratoscopelus* (especially in small larvae).

Genus ***Diaphus***

The genus *Diaphus* is the most speciose among the lanternfish of the Agulhas region. Identification of larval stages of *Diaphus* species (Moser and Ahlstrom 1974; 1996; Moser *et al*. 1984; Olivar and Beckley 1995) depends on slight morphological and pigmentation differences. Olivar and Beckley (1995) identified and described the posflexion larvae of *Diaphus diadematus*, the larvae of *D. mollis*, and the larvae of another *Diaphus,* possibly *Diaphus brachycephalus* or *D. richardsoni,* from samples collected on the three cruises. Furthermore, other "types" of *Diaphus* larvae named A, B, C (Olivar and Beckley 1994a) where also differentiated but not identified.

Genus ***Lampadena***

Adults of three species of *Lampadena* have been recorded in the Agulhas Current region: *L. luminosa*, *L. notialis* and *L. speculigera* (Hulley 1984a). *L. notialis* is a species of the "South temperate pattern" and was represented by only one specimen. *L. speculigera* also has a "Temperate pattern". A "Tropical" pattern is characteristic of *L. luminosa* (Hulley 1992).

Lampadena luminosa (Garman, 1899)
(Figs. 11, 12)

Counts: D 14-15, A 13-15, P 15-17, GR 4+1+8-10.

Larvae were captured on all three cruises but not in areas where colder waters were present (Olivar and Beckley 1994a). In general, larger larvae did not occur at the most inshore stations. We collected a total of 44 postflexion larvae and 147 preflexion and flexion larvae, ranging from 3.8 to 12.4 mm BL. Identification of larvae of this species was based on the similarity of our largest larva (12.4 mm) and a 12.8 mm larva described by Moser and Ahlstrom (1974), and by the gill raker count of our specimen. Smaller stages were compared in a continuous graded series of development from this larger larva to 3.8 mm.

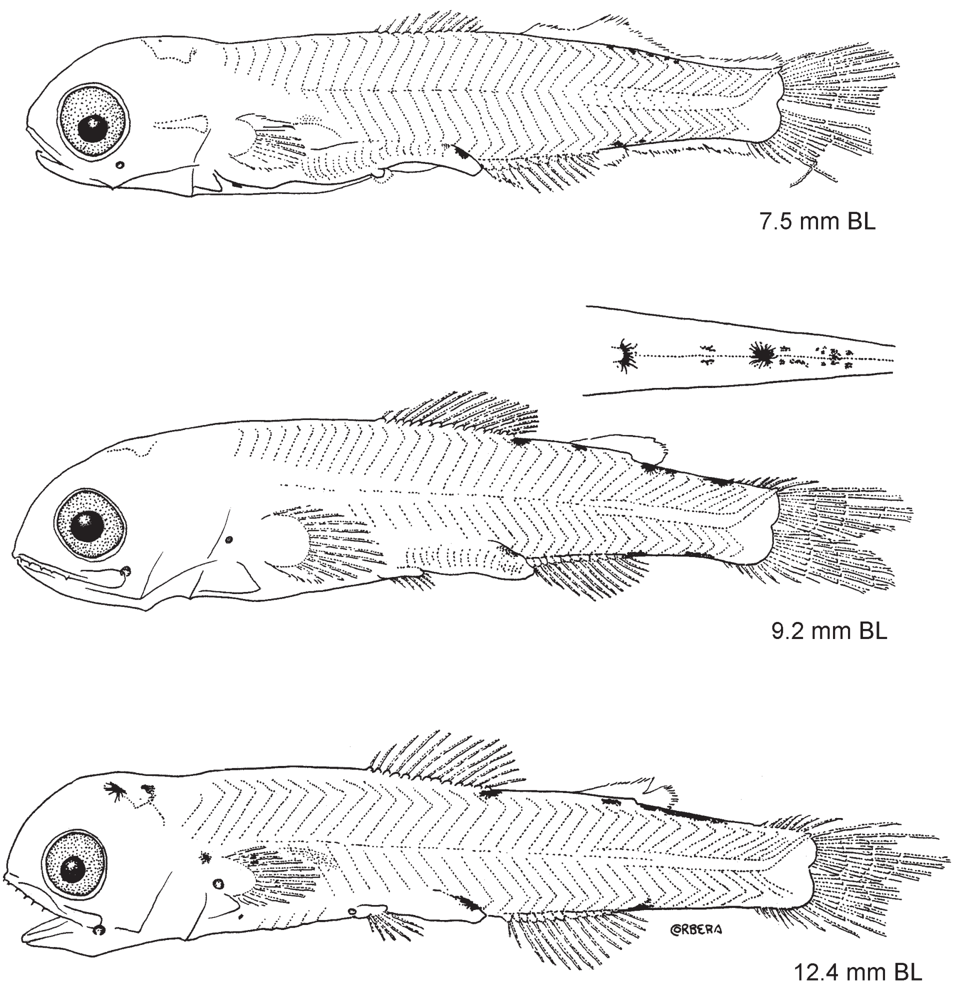

FIG. 12. – Postflexion stages of *Lampadena luminosa* from the Agulhas current region: 7.5 mm, 9.2 mm, dorsal and lateral view, and 12.4 mm. ICICMB 188/AGU.

Morphology

Larvae slender during all stages of development (BDP <23% of BL), but especially during preflexion stages (BDP 11-14% BL); gut straight, extending to midpoint of body in early larvae (3.8 mm) and beyond midpoint (60% of BL) in larger larvae; eyes round in all the larval stages; notochord flexion begins around 5.5 mm and the urostyle is flexed at 6.0 mm.

Pigmentation

Pigmentation varies gradually during development; pigmentation over gas bladder in all sizes; internal pigment on anterior part of the gut (in front of liver) barely visible in largest larvae but distinct in larvae < 7.5 mm, and generally more apparent in preflexion larvae; postanal pigmentation consists of a series of midventral tail melanophores (*ca*. 18-20) in preflexion stages that disappear gradually during flexion and fuse to form one or two large melanophores posterior to anal fin; dorsal pigmentation on tail appears in preflexion stages at *ca*. 5 mm and consists of a double line of pigment extending along 5 or 6 myomeres; in postflexion stages dorsal pigmentation consists of several melanophores located from dorsal fin insertion to caudal peduncle; pigmentation above brain distinct in largest larvae (12.4 mm), but indistinct or absent in earlier stages; pigmentation absent in otic region.

Fins and photophore development

The caudal fin forms first, followed by the anal, dorsal, pectoral and pelvic fins; the Br_2 photophore appears at *ca*. 6 mm BL, the PLO at *ca*. 10 mm, and the PO_5 at *ca*.12.5 mm.

Meristic characters

Myomere count 36-37; gill raker count 3 or 4+1+6 in the 12.4 mm larva.

Discussion of the identification of Lampadena *larvae*

The 12.4 mm larva from the Agulhas region is very similar to the 12.8 mm *L. luminosa* described by Moser and Ahlstrom (1974) and the postflexion larvae described by Ozawa (1986). All have the Br_2, PLO, PO_5 photophores well formed dorsal and anal rays. One difference is the presence of occipital pigmentation and the pigmentation anterior to the pectoral bases present in the 12.4 mm larva from the Agulhas region and the absence of this pigmentation in the larvae illustrated by the other authors. Gill raker counts eliminated the possibility that our larva belonged to *L. notialis* or *L. speculigera*, two other *Lampadena* species present in the region.

Pigmentation of preflexion and flexion stages of our larvae differs somewhat from that described by Ozawa (1986). His smallest *L. luminosa* (4.8 mm) already have dorsal pigmentation and lack the row of melanophores in the ventral midline of the tail. This may be due to shrinkage by preservation in his specimens. The preflexion larva of *L. luminosa* illustrated by Miller *et al*. (1979) did not resemble those of Ozawa (1986) nor the smallest larvae described here and is not *L. luminosa*. It may be another species of *Lampadena*.

Comparative remarks

The smallest larvae are similar to those of *Diaphus* spp. and *Ceratoscopelus* spp. Ventral tail pigmentation differs from that of *Diaphus* larvae. In *Lampadena* larvae there is one melanophore at each myoseptum whereas in *Diaphus* there are generally fewer ventral tail melanophores and they are less evently spaced. Also, in *Diaphus* there is a small melanophore at the base of the caudal fin, well separated from the posteriormost melanophore in the ventral series. The main difference in preflexion stages of *L. luminosa* and *C. townsendi* is the absence of pigmentation on the isthmus and the smaller number of postanal melanophores (6-11) in the latter. Diagnostic characters for the larger larvae are: 1) dorsal pigmentation present on the tail in *L. luminosa* but not present in *C. townsendi* nor in *B. pterotum;* and 2) sequence of photophore development (*L. luminosa,* Br_2, PLO, PO_5; *B. pterotum,* Br_2, Dn, PO_5 ; *C. townsendi,* Br_2, Vn, PLO, PO_5).

Genus ***Lampanyctus***

Adults of ten species of *Lampanyctus* are found in the area (Hulley, 1984a). Larvae of *Lampanyctus lepidolychnus* were the most abundant during the three cruises, followed by *L. alatus*. Other species of *Lampanyctus* which also appeared in the cruises were *L. achirus, L. ater, L. nobilis* and *L. pusillus*.

Descriptions of the larvae of this genus collected in the Agulhas region are given by Olivar and Beckley (1997). Larvae of *Lampanyctus* have some resemblance to those of *Notoscopelus* which have smaller teeth in the upper jaw, pigmentation on the dorsal surface of the gas bladder, and an early development of the PO_5 photophore (Moser and Ahlstrom 1974, 1996).

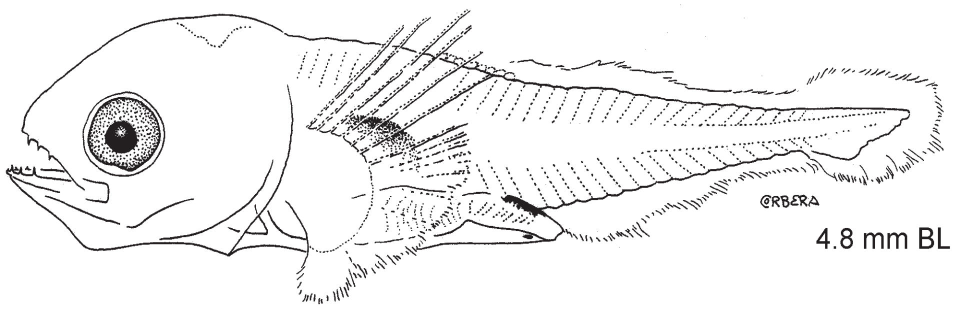

FIG. 13. – Larva of *Lobianchia dofleini* from the Agulhas current region: 4.8 mm. ICICMB 190/AGU.

Genus *Lobianchia*

Mature adults of the tropical *L. dofleini* and *L. gemellari* have been collected in the Agulhas current region (Hulley 1984a).

Lobianchia dofleini (Zugmayer, 1911)
(Fig. 13)

Counts: D 15-17, A 13-15, P 10-13, GR 4-6+1+12-15.

Larvae of this species were described by Tåning (1918); Dekhnik and Sinyukova (1966); Moser and Ahlstrom (1974) and Berdar and Cavaliere (1975). The single larva collected in the present study has pigmentation only on the peritoneum above the air bladder and the eye is small and round with no choroid tissue. Eyes in larger larvae appear to have an elongate shape due to the presence of the squarish mass of choroid tissue, but at this stage they are still round and lack choroid tissue.

Lobianchia gemellarii (Cocco, 1838)
(Fig. 14)

Counts: D 16-18, A 13-15, P 11-13, GR 4-7+1+10-15, vertebrae 34-35.

Larvae appeared during the three cruises, being most abundant in May/June 1990. These larvae were relatively common throughout the study region, although their concentrations were low. Total larvae examined: 99, 3.8-8.4 mm. Identification was based on the descriptions of Cavalieri and Berdar (1976); Moser and Ahlstrom (1974, 1996) and Ozawa (1986).

Diagnostic characters

Broad head with large eyes; pectoral fins with the upper rays elongated, and the lower part membranous; strong pigmentation on the anterior gut region and at the base of pectoral fin; one melanophore in the midline of the body posterior to anal fin.

Comparative remarks

L. gemellarii larvae have larger eyes and a more pigmented body than *L. dofleini*. In flexion stages and postflexion stages, the shape of the pectoral fin differentiates these two species: in *L. gemellari* there is a conspicuous difference between upper and lower part of the pectoral fin whereas in *L. dofleini* the lower pectoral rays develop subequally with the produced upper rays (Moser and Ahlstrom 1974).

Notolychnus valdiviae (Brauer, 1904)

This species is generally widely distributed throughout the warmer waters of all three oceans (Hulley 1981). Counts: D 10-12, A 12-14, P 11-14, GR 2+1+7-8.

Larvae occurred on the three cruises, mainly north of Mbashe. Total larvae examined: 59, *ca.* 4-8.6 mm. Larvae were identified using the descriptions of Tåning 1918; Moser and Ahlstrom (1974, 1996) and Shiganova (1975).

Diagnostic characters

Short gut (PAL <50% BL); oval eyes; discrete melanophores on the ventral midline of the tail and mid-hypural pigmentation.

Genus *Notoscopelus*

(Hulley 1984a) collected the two tropical species, *Notoscopelus caudispinosus* and *N. resplendens*, in this region, although all of his *N. caudispinosus* specimens were immature.

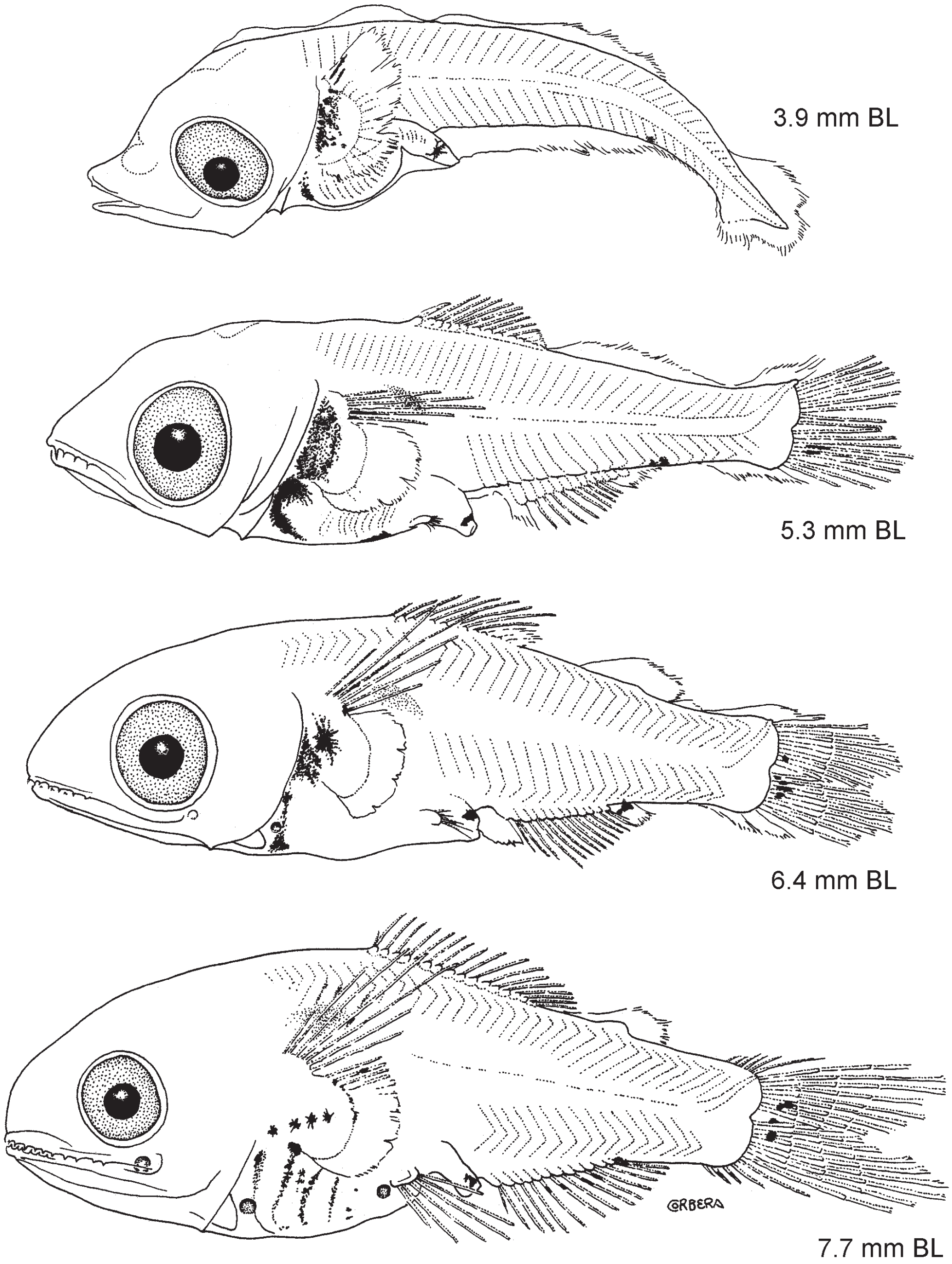

FIG. 14. – Developmental stages of *Lobianchia gemellarii* from the Agulhas current region: 3.9 mm, 5.3 mm, 6.4 mm and 7.7 mm. ICICMB 191/AGU.

Notoscopelus caudispinosus (Johnson, 1863)
(Fig. 15)

Counts: D 24-27, A 19-21, P 11-13, GR 4+1+8-10.

Larvae of this species occurred only during the May/June 1990 cruise, throughout the study region. Total larvae examined: 57, all in preflexion and flexion stages, 3.6-4.8 mm BL. Identification was based on the descriptions of Ozawa (1986).

Morphology

Eyes large and round in preflexion and flexion larvae (ED 16% BL); anterior part of the body relatively deep (BDP 30% BL); gut short (PAL <50% BL in preflexion larvae).

Pigmentation

Pigmented dorsal surface of the gas bladder useful for identification to genus; melanophores present on hindbrain and forebrain, and conspicuous pigmenta-

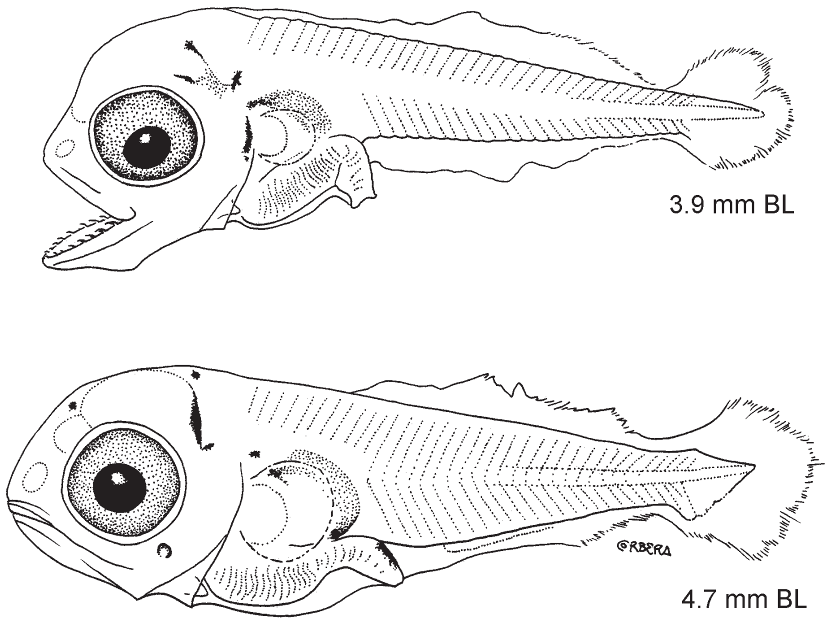

FIG. 15. – Developmental stages of *Notoscopelus caudispinosus* from the Agulhas current region: 3.9 mm and 4.7 mm. ICICMB 192/AGU.

tion visible near otic region; no pigment present on jaw tips nor on tail; free terminal section of gut pigmented in flexion larvae but not in preflexion ones.

Photophore development
Br_2 already visible in 4 mm larvae.

Notoscopelus resplendens (Richardson, 1845)

Counts: D 21-24, A 17-20, P 11-13, GR 5-7+1+12-15.

Only 10 larvae of this species, from ca. 3.5 to 7 mm BL, occurred in May/June 1990 and October 1990 cruises. They were identified using the descriptions of Moser and Ahlstrom (1972, 1996) and Ozawa (1986).

Diagnostic characters
These larvae may be differentiated from those of *N. caudispinosus* by the smaller eyes (ED <12% BL). The dorsal and ventral pigmentation on the tail and the pigmentation on the jaw tips in *N. resplendens* are the main pigmentation features that differentiate them from *N. caudispinosus*.

Scopelopsis multipunctatus Brauer, 1906
(Fig. 16)

Adults of the subtropical *Scopelopsis multipunctatus* are relatively abundant in the study region (Hulley 1984a). Counts: D 20-25, A 23-27, P 10-12, GR 7-9+1+14-17.

Larvae of this species were very abundant during the May/June 1990 survey but did not appear in the two other cruises. They were distributed all along the study area, with highest densities at the most offshore stations. Total larvae examined: 1172, 2.5-10.5 mm BL. Identification was based on Moser and Ahlstrom (1972). They ranged from preflexion to postflexion stages. Two preflexion stages of these larvae (4.2 and 5.7 mm BL) are depicted here because in the description of Moser and Ahlstrom (1972) the smallest larvae are in flexion stages and we found some differences in preflexion stages compared with later larval stages. The number of melanophores on the ventral midline of the tail is a little higher (six instead of five). In some larvae these melanophores are not punctate, but linear, and sometimes form a more or less continuous line of pigment. Otherwise the characters conform to those discussed in Moser and Ahlstrom (1972).

Diagnostic characters
Short gut (PAL <50% BL); a prominent melanophore at the nape; conspicuous pigmentation above the developing gas bladder; lateral teeth of the lower jaw curved anteriad. Morphology of these larvae resembles that of *N. valdiviae*, but the larvae may be differentiated by the larger and more round eyes, the pigmentation on the nape in *S. multipunctatus,* and the teeth.

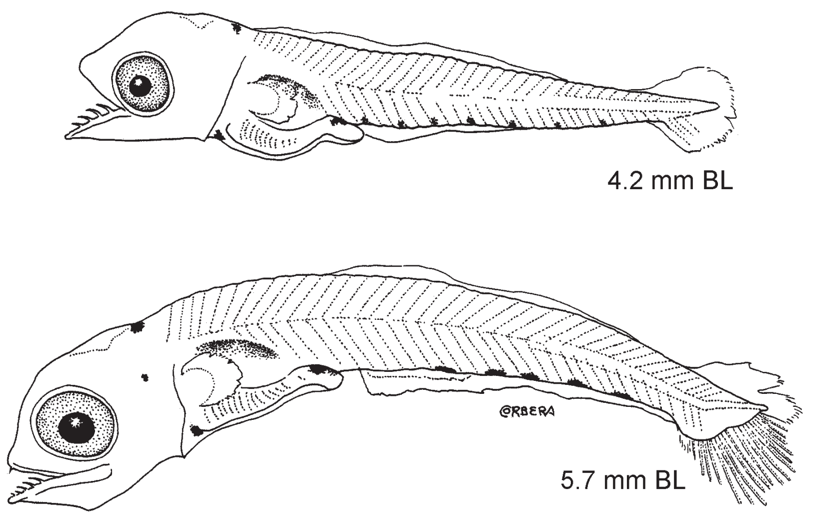

FIG. 16. – Developmental stages of *Scopelopsis multipuctatus* from the Agulhas current region: 4.2 mm and 5.7 mm. ICICMB 193/AGU.

Triphoturus nigrescens (Brauer, 1904) (Fig. 17)

No sexually mature specimens of this species have been found in the area (Hulley 1984a). Counts: D 13-15, A 16-18, P 8-10, GR 2-4+1+7-10.

Larvae were more frequent in the October 1990 survey than in the other two surveys. The southernmost location for these larvae was East London; they were most abundant offshore of the 200 m isobath. Total larvae collected: 32, 4.1-11.3 mm BL. Larvae were identified with the descriptions of Moser (1981); Belyanina (1986) and Moser and Ahlstrom (1996).

Morphology

Larvae moderately slender (BDP 58% BL in preflexion larvae and 23 % BL in postflexion larvae);

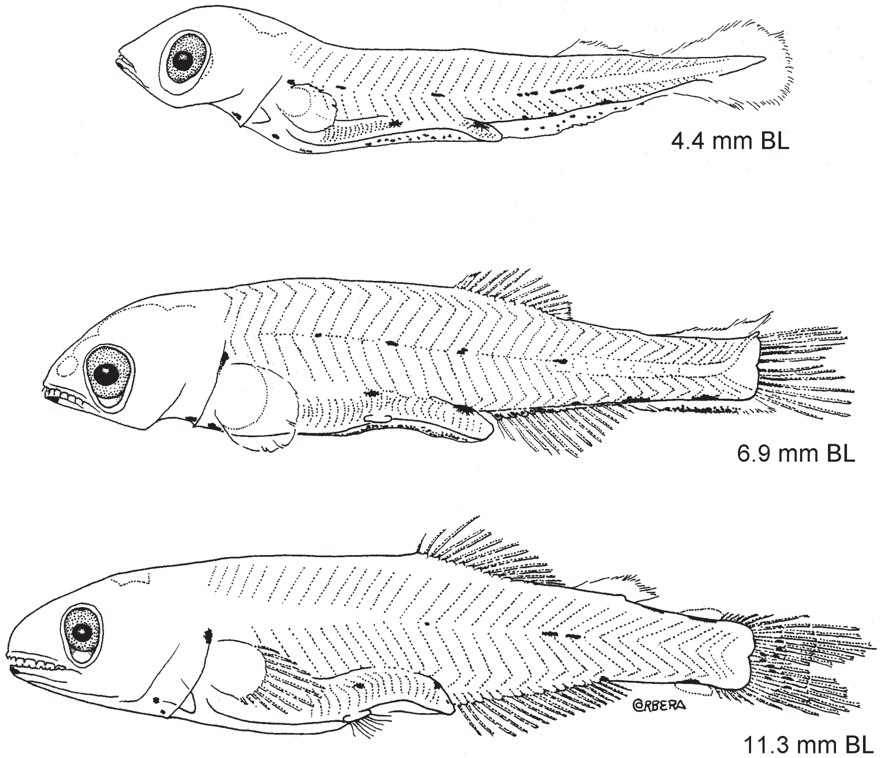

FIG. 17. – Developmental stages of *Triphoturus nigrescens* from the Agulhas current region: 4.4 mm, 6.9 mm and 11.3 mm. ICICMB 195/AGU.

gut extends to *ca*. 60% of BL; choroid tissue visible at the base of the eyes in flexion and postflexion stages; notochord flexion begins around 5.5 mm and the notochord is flexed at 6.5 mm.

Pigmentation

Conspicuous pigment dashes on the lateral midline of the body, becoming scanty in the largest larvae (11.3 mm); melanophores visible at tip of lower jaw, isthmus, lateral walls of midgut and anus and on ventral midline of body.

Photophore development

No photophores present in the largest larva examined.

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